

Explaining properties of aqueous solutions

1) Some properties of three aqueous solutions A, B and C, of equal concentration are shown in the table below.

Solution	A	B	C
pH	5.15	11.6	1.05
Electrical conductivity	good	poor	good

The labels of the three solutions have been removed.

It is known that the solutions are $\text{NH}_3(\text{aq})$, $\text{HCl}(\text{aq})$ and $\text{NH}_4\text{Cl}(\text{aq})$.

Use the information in the table above to identify each of the three solutions.

Justify the identification of all three solutions.

In your answer you should:

- refer to both pH and electrical conductivity of the solutions
- link your answers to appropriate chemical equations.

2) Place the following solutions in order of increasing pH,

$0.01 \text{ mol L}^{-1} \text{CH}_3\text{COOH}$

$0.01 \text{ mol L}^{-1} \text{HCl}$

$0.1 \text{ mol L}^{-1} \text{HCl}$

$0.1 \text{ mol L}^{-1} \text{NaOH}$

Justify your order above in terms of:

- proton transfer
- relative concentrations of $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$, linked to the pH of the solution. You should include equations in your answer.

3)

Three aqueous solutions, of equal concentration, have the following pH values:

Solution	$\text{HNO}_3(\text{aq})$	$\text{HCOOH}(\text{aq})$	$\text{KOH}(\text{aq})$
pH	2.0	2.9	12

Compare and contrast both the strength and electrical conductivity of these aqueous solutions.

Include appropriate equations in your answer.

4) a) The concentration and pH of two acids **HA** and **HB** are shown in the table below.

Acid	Concentration / mol L ⁻¹	pH
HA	0.00100	3.00
HB	0.0100	3.40

i) Identify which one of these acids is **weaker** and circle your choice below. **HA HB**

ii) Explain the reasons for your choice. You must include reference to both acids in your answer.

b) A sample of sodium ethanoate, CH₃COONa, is dissolved in water. The solution is tested and found to be basic. Explain why the solution is basic. Include appropriate equation(s) in your answer.

5) a) i) Explain why the concentration of the acid, HCl, is equal to the concentration of the hydronium ion, H₃O⁺.

ii) The concentration of the hydronium ion, H₃O⁺, in a 0.0376 mol L⁻¹ solution of CH₃COOH is less than 0.0376 mol L⁻¹. Explain why the concentration of the hydronium ion is less than 0.0376 mol L⁻¹.


b) Conductivity of solutions can be described as being **high**, **low**, or having **no conductivity**. Compare and contrast the conductivity of the three solutions shown below.


0.100 mol L⁻¹ HCl

0.100 mol L⁻¹ CH₃COOH

0.100 mol L⁻¹ NaOH

6) Complete the equations below to show how each species will react with water to form an acidic solution.

i) NH₄⁺(aq) + H₂O 

ii) HF(aq) + H₂O 

7) Aqueous solutions of acids **HA** and **HB** both have the same concentration of 0.100 mol L⁻¹. The pH of the solution of acid **HA** is 3.5 and the pH of the solution of acid **HB** is 1.8.

(a) (i) Identify which one of these acids is stronger

(ii) Discuss the reasons for your choice. You should include relevant equations in your answer, as well as reference to what is meant by the strength of an acid.

(b) Describe what is observed when the following two tests are carried out on 5 mL samples of the acids **HA** and **HB**.

(i) Identical small pieces of magnesium ribbon are placed in each acid.

(ii) Sodium hydroxide solution is slowly added to each acid. The volume of sodium hydroxide solution required to completely react with the acid is measured.

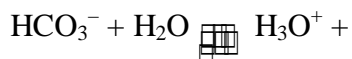
c) Discuss the observations in (b) (i) and (ii).

Your answer must include reference to:

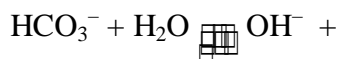
- similarities and / or differences in the observations of the tests on each acid
- equations for reactions.

8) a) The bicarbonate ion, HCO_3^- , can both accept and donate hydrogen ions (protons).

Complete the equations below.



Reaction A



Reaction B

b) When sodium bicarbonate, NaHCO_3 , dissolves in water the solution is basic. Identify which reaction predominates. Justify your answer.

9) Choose the ion CH_3COO^- or HCO_3^- that can act as both an acid and a base. Justify your choice.

10) The concentration and pH of three acids, HA, HB and HC, are shown in the table below.

acid	concentration (mol L^{-1})	pH
HA	0.100	1.00
HB	0.100	2.50
HC	0.00100	3.00

a) A small piece of magnesium is added to a 20 mL sample of each of the acids. Choose the acid that would be expected to react most rapidly with the magnesium. Explain why this acid will react the fastest.

b) Choose the weakest acid. Explain why this acid is the weakest.

11) A solution of sodium ethanoate (NaCH_3COO) is tested and found to have a pH of 8.50. Discuss why the pH of the solution is greater than 7. Include appropriate equation(s) in your answer.

12) Two acids of the same concentration, hydrochloric acid (HCl) and propanoic acid (CH₃CH₂COOH), have properties as shown below:

Property	Hydrochloric acid (0.100 mol L ⁻¹)	Propanoic acid (0.100 mol L ⁻¹)
Relative conductivity of solution	High	Low
pH of solution	1.00	2.93

b) Consider the properties described in the table above. Explain the differences in the **conductivity** and **pH** of the two acids. In your explanation include reference to the species present in each solution.